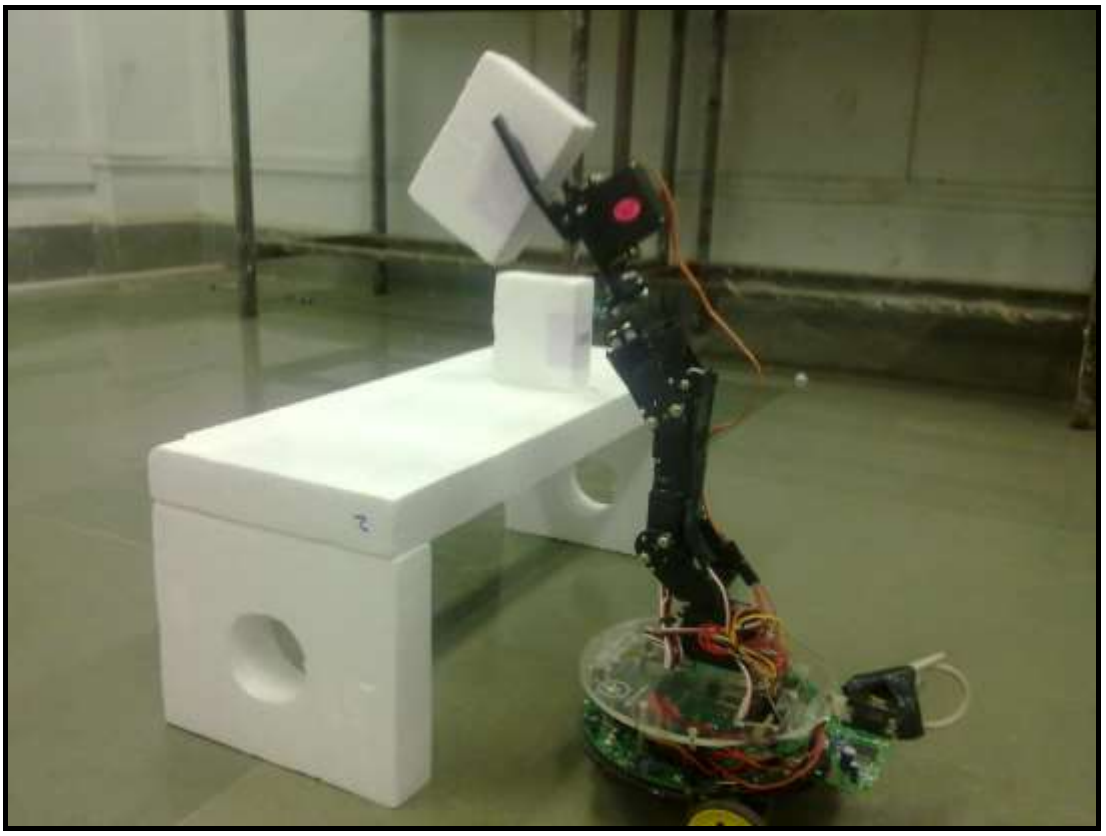
CS-308-2014 Final Report



Automation of Library System

TEAM CODE-TH 10

1. Yogendra Singh Dabi **100050032**
2. Ashish Busi **10D170012**
3. Rajesh Sharma **100050031**
4. Anurag Meena **100050029**

Table of Contents

1. Introduction 3
2. Problem Statement 3
3. Requirements 3
    3.1 Functional Requirements 3
    3.2 Non-Functional Requirements 3
    3.3 Harwdare Requirements 3
    3.4 Software Requirements 3
4. System Design 3
5. Working of the System and Test results 3
6. Discussion of System 4
7. Future Work 4
8. Conclusions 4
9. References 4

1. Introduction

We have built bot for automation of library system. We have tried to replace typical librarian with a bot. We found that there is lot of human work involved while placing and retrieving books in library and complexity for searching and retrieving increases when books in library increases which is general case in almost all libraries. So in order to reduce human effort we have worked on this project. In this document an autonomous solution for the robotics librarian is proposed. The aim is to retrieve a book required by any user, and bringing that book to the user, whether it was founded in the corresponding bookshelves and placing book back to its corresponding location in shelves.

2. Problem Statement

The main aim is to retrieve a book required by any user, and bringing that book to the user, whether it is founded in the corresponding bookshelves and placing book back to its corresponding location in shelves. Unique identification of particular book using its ID or barcode. Identifying books location based on ID. Motion of bot to accurately fetch or place back book on its correct location. Redundancy in case bar code is corrupted. Mostly all of these have been achieved to greater extent.

3. Requirements

3.1 Functional Requirements

Detailed Functionality:

1. Basic functionality is to completely automate the book retrieving and returning/placing back activity in library
2. Picking and holding the book
    a. Initial placement of book
    b. Picking book from table or picking it from a shelf
    c. Positioning the book correctly in front of camera
    d. Distance from camera adjusted for optimum placement
    e. Sturdy hold of book for good(non-hazy) picture
    f. Sensing presence of book in vicinity of camera
    g. On camera when book is sensed
    h. Automatically take picture when book in correct position
    i. Transfer this image serially to processing function
    j. Processing can be done on bot/laptop depending on time needed
    k. No motion of bot will occur so long as picture is being taking and being processed
3. Identification of the book
    a. Picture of book will be taken when it is sensed
    b. Picture will cover alphanumeric id and barcode
    c. Picture data is serially communicated to bot(will be in form of array)
    d. Image processing module will come into play
    e. Image array input to image processing module
    f. Alphanumeric data and barcode data is bifurcated
    g. Alphanumeric array processed to get alphanumeric id of book

h. Barcode array processed to get alphanumeric id of book from barcode
i. If any 1 part of image is corrupted then algorithm will completely rely on valid identification
j. Ids from both processing matched to see if they are same
k. If same then book id is obtained
l. Book id obtained is now sent as input to mapping module of algorithm

4. Mapping of identified book to location/coordinates
    a. Book id is input to this module
    b. There is internal reference database
    c. This database has book id to location/coordinates mapping
    d. The module matches current book id
    e. From here location will be obtained
    f. This location is input to next module which will actually give commands to the bot for the position to be reached for placing or retrieving the book
5. Mapping of location/coordinates to actual position in library shelves
    a. The input to this module is the coordinates/location
    b. There is another internal database
    c. This maps the location of bot to the set of commands for reaching the position for placing or retrieving the book
    d. These commands are in form of “forward(10), right(5)”, which take the bot to the position in the library physically where the book needs to be placed
    e. Once this commands set in the boot needs to be disconnected from USB. So, this is where the zigbee module will be helpful in sending these commands to the bot over wireless.
6. Position accurately attained horizontally and vertically
    a. The bot will always move with respect to a particular reference in our current implementation
    b. For placing back a book, the bot will be in reference position where the book will be placed in the gripper for bot to sense it, do its processing and find the position. After that, the motion of bot according to commands will be in reference to this starting position.
    c. Even for the case of retrieving a book, the bot will be in the reference position itself initially when the book to be retrieved, its id is given to the bot. Accordingly it will go to that position, which is given as command to the bot with reference to current position and will pick up the book and bring it back to the reference position.
    d. Basic motions used are forward, backward, left and right.
    e. The extent to which the bot needs to move depends on the granularity with which it can move given a certain command.
    f. As an example, taking the case of forward. The command forward(1) will cause the bot to move forward by 1 unit. Depending on what the granularity of 1 unit is, the bot will move ahead by that amount. Similarly, for other motion commands also.
    g. Based on this granularity, the positions are decided.
    h. Accordingly, based on smallest granularity, the shelves are made and the smallest distance between consequent books are decided on the shelf or the distance between two shelves is decided.
7. Gripping action for holding book in position
    a. The gripping action is important from point of view of holding the book in position and arrest movement
    b. Book should be completely stationary for getting a proper picture
    c. Also to avoid possibility of dropping of book
    d. Gripping action is the closing of gripper arms. The thickness of books will be variable.

e. We will take into consideration the extent to which gripper arms must close, for various books, this extent of closing will vary, for holding the books in place.
f. There will be a separate module for controlling the gripper arm
g. Commands will primarily include open, close and degree to which the gripper arms should close.
h. The commands will be sent directly to the gripper arm in its format from the main program when required to catch or release a book.

8. Movement along specified path only
    a. Like specified above there will a reference position for now from which the bot will start and will finally return after task is over.
    b. Depending on the total set of commands for the total set of books in the library, there will a predefined set of paths over which only the bot will move
    c. So, we will avoid placement of any objects in the path of the bot
9. Tackling of obstacles
    a. The bot has a predefined set of paths over which it will move to retrieve and place books
    b. So we avoid any objects to be placed in this path
    c. However if there are some objects in this path, the bot will stop and wait for manual intervention according to our current model

3.2 Non-Functional Requirements

1. Reliability: Our code is reliable on open source libraries provided by zxing. If they remove it from open source than we have to make our own scanning method.
2. Connection: Connection between Bluetooth module and android phone is of importance. Before transmitting data to bot we have ensured connection is made properly otherwise it will delay the operation speed.
3. Response time: While retrieving books if response time of scanning is greater than a threshold value then it will start looking for nearby books considering book is not found at original location. So we have to place camera at certain location in front of book so that it identifies barcode fast.
4. Extensibility: It can be extended to design bot for shopping malls bot.

3.3 Harwdare Requirements

Hardware:

5. Firebird V
6. Accessories kit
7. Bluetooth module(AUBTM-20)
8. Gripper Arm(4-axis)
9. Android phone

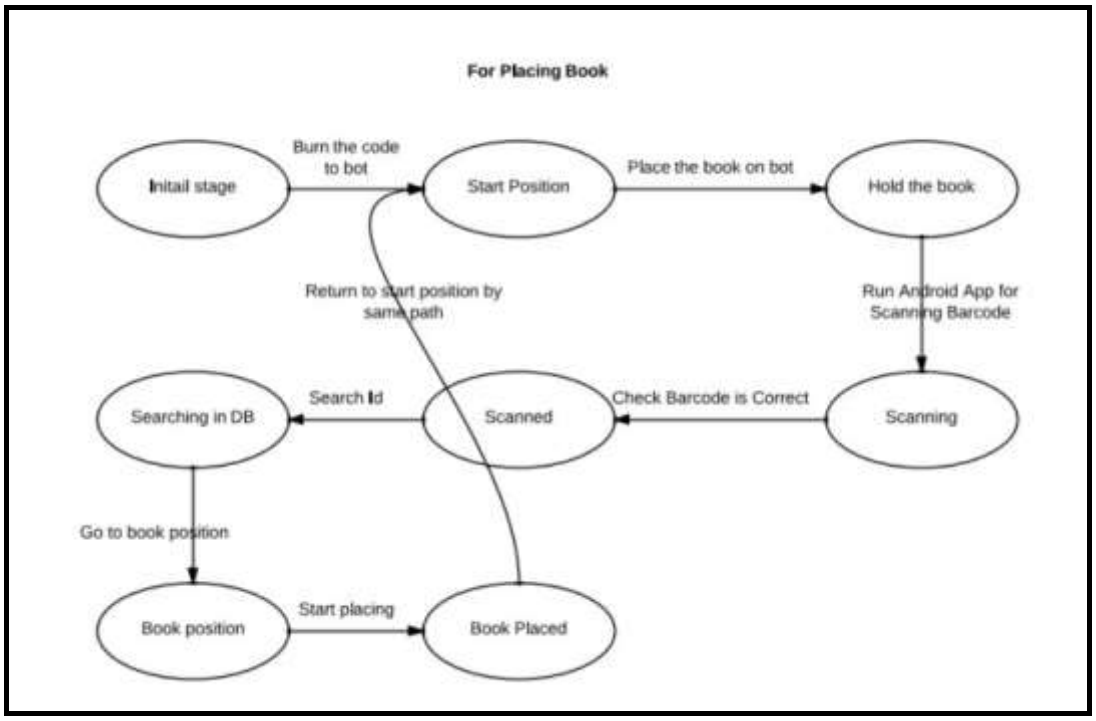
3.4 Software Requirements

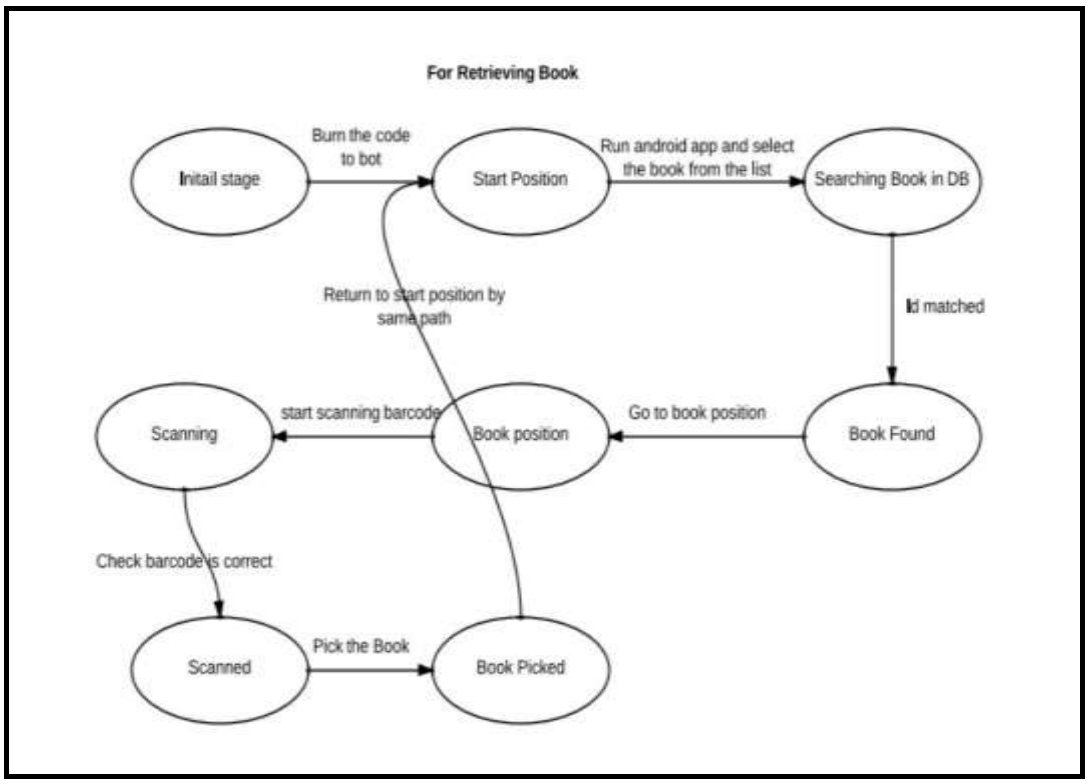
Software:

1. Zxing barcode libraries for android
2. Bluetooth libraries for android

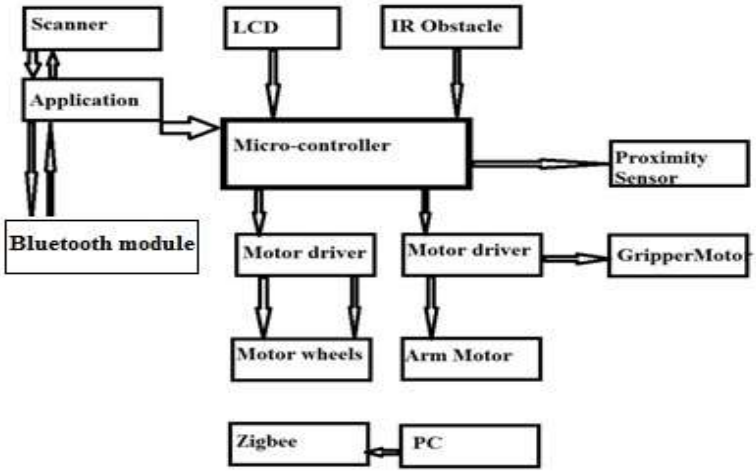
4. System Design

System diagram:

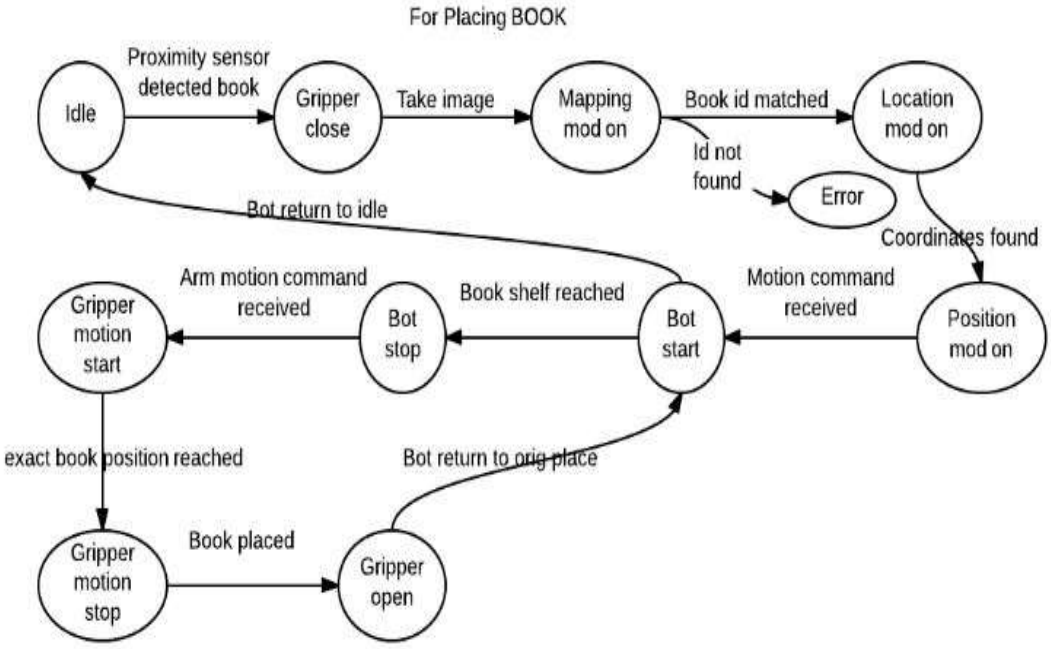


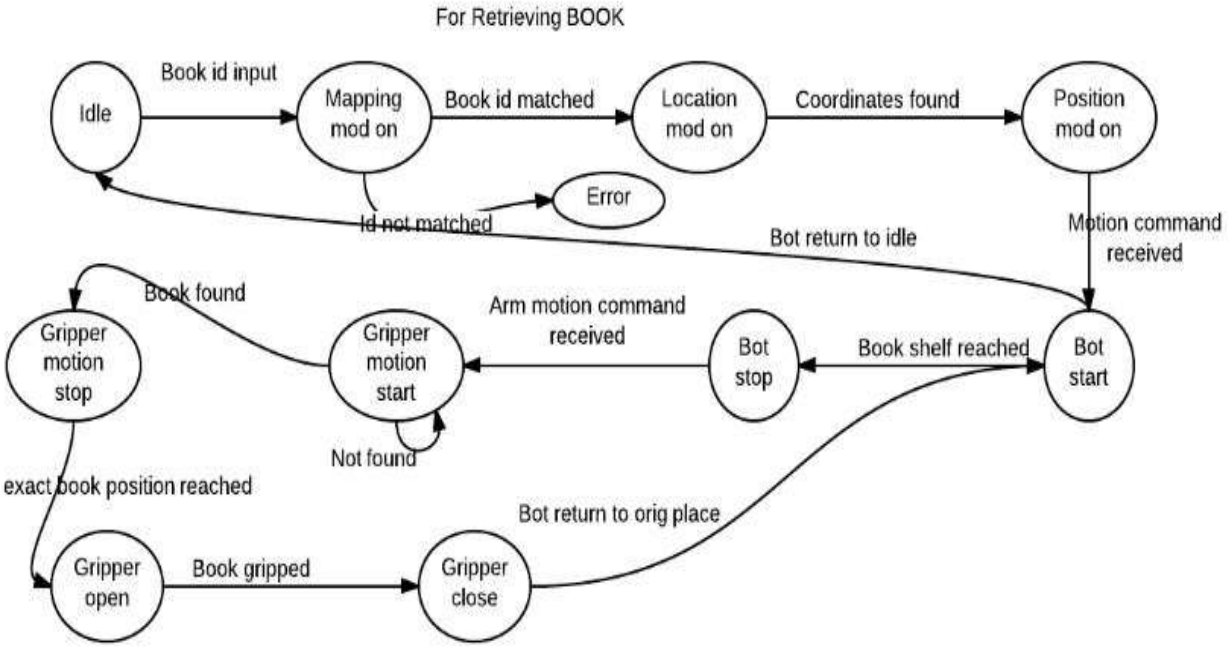


Block diagram:



FSM:





Above FSM in detailed version:

initial state	transition	action	final state
book place:			
Idle	Book brought near	Proximity sensor activated to detect	Gripper close
Gripper close	Camera on	take image	Mapping Module on
Mapping Module on	image array input	book id obtained	Location module on
Location module on	book id input	coordinates obtained	Position module on
Position module on	coordinates input	motion commands obtained	bot start
bot start	motion commands input	book shelf and position reached	bot stop
bot stop	gripper arm activated	arm motion to place book	start gripper motion
start gripper motion	position book	book position to place reached	stop gripper motion
stop gripper motion	place book	book placed in designated position	gripper open
gripper open	back to initial position	bot returns back to original point	bot start
bot start	stop at initial position	bot to return to idle state	idle

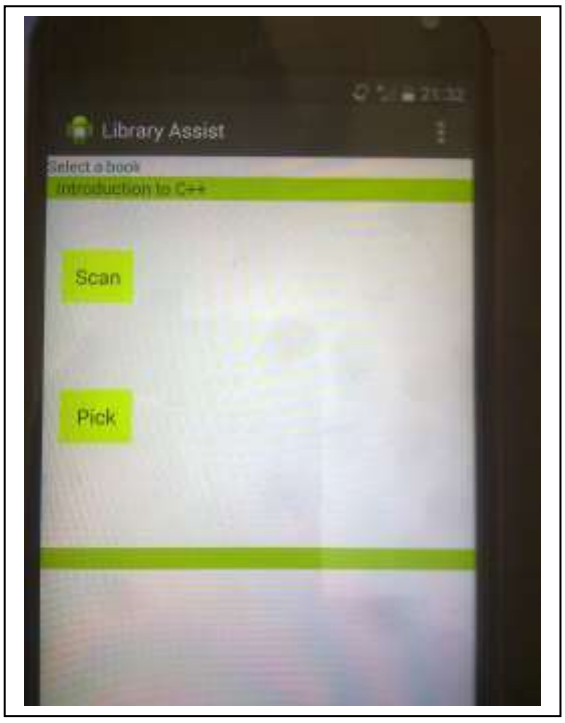
book retrieve:			
Idle	book id input	coordinates obtained	Position module on
Position module on	coordinates input	motion commands obtained	bot start
bot start	motion commands input	book shelf and position reached	bot stop
bot stop	gripper arm activated	arm motion to retrieve book	start gripper motion
start gripper motion	book to grip position	book position to grip reached	stop gripper motion
stop gripper motion	grip book	book in designated position gripped	gripper close
Gripper close	Camera on	take image	Checking Module on
Checking Module on	Match book ids	make sure correct book gripped	match: bot start
			not-match: check left/right book
if match			
bot start	stop at initial position	bot to return to idle state	idle
if not match			
start gripper motion	position book	book position to place reached	stop gripper motion
stop gripper motion	place book	book placed in designated position	gripper open
gripper open	move to next book position	bot moves to next book	bot start
bot start	stop at next book position	bot positioned at next book	bot stop
bot stop	gripper arm activated	arm motion to retrieve book	start gripper motion
start gripper motion	book to grip position	book position to grip reached	stop gripper motion
stop gripper motion	grip book	book in designated position gripped	gripper close
Gripper close	Camera on	take image	Checking Module on
Checking Module on	Match book ids	make sure correct book gripped	match: bot start
			not-match: check left/right book

5. Working of the System and Test results

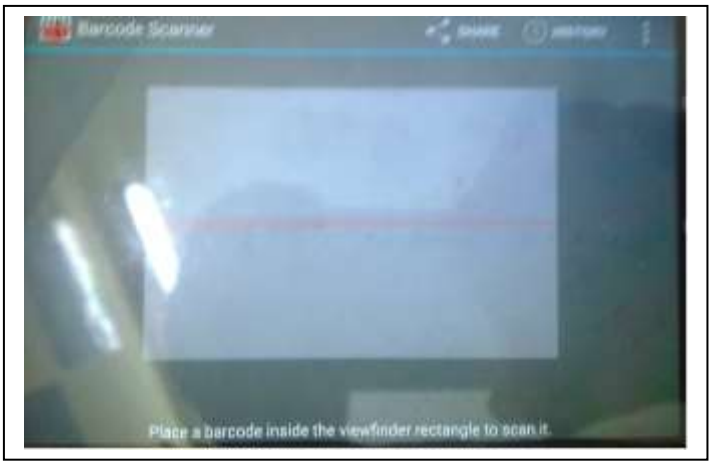
Placing book:

a)Initial position:

b)Android App activation:

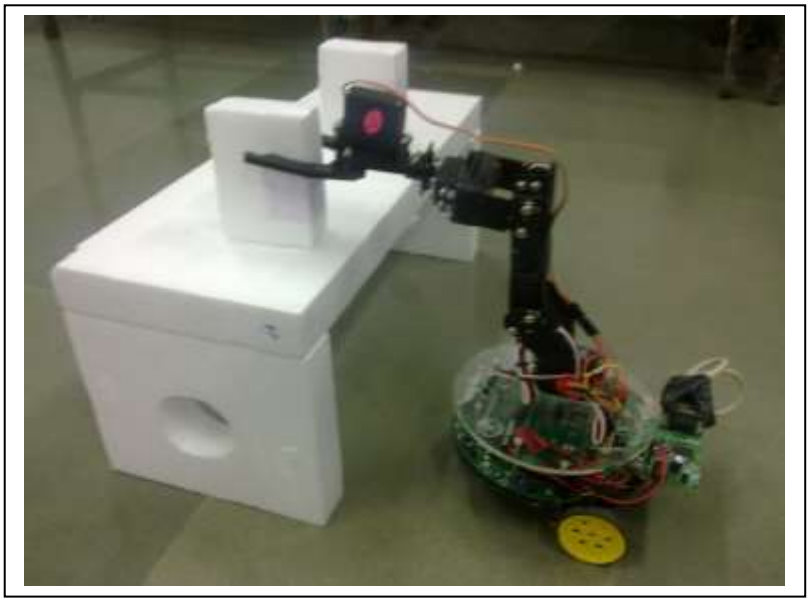


c)Scanning:

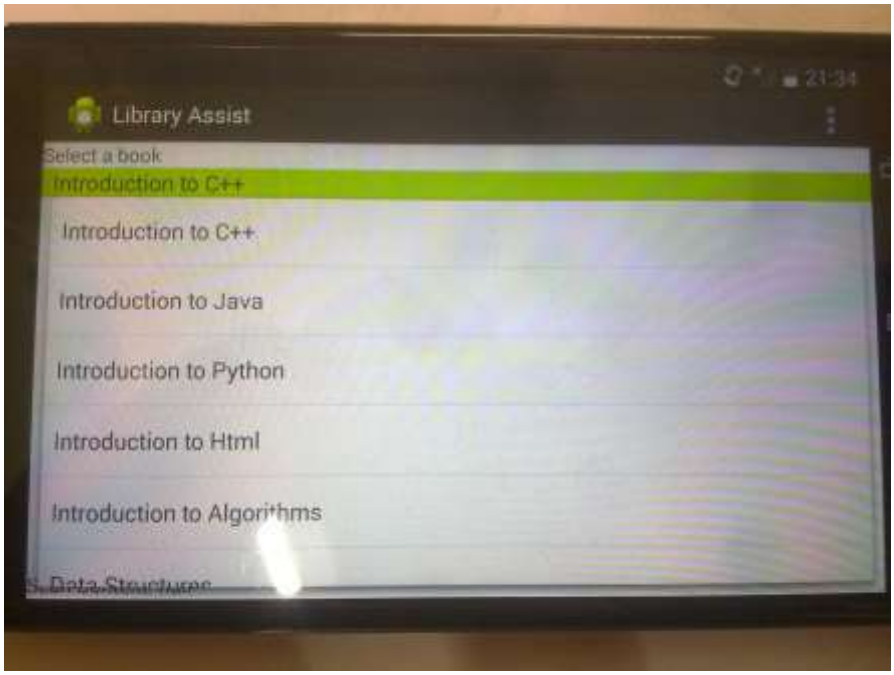


d)Scanning complete. Result shown on app. Then reach book location.

e)Placing book:



f) Finished.



Similar procedure is applied for retrieving book but instead of "Scan" just "**select**" book from drop down list which you want to retrieve and and press "**Pick**" button of app.

Testing strategy	How checked ?
Picking and holding the book	*On giving commands to bot whether it is able to pick and hold books correctly.*
Identification of the book	*Provided different barcodes to different books. Scanned them and results were different ids.*
Mapping of identified book to location/coordinates	*Selected books from drop down list and viewed whether on pressing "scan"/"pick" whether it goes to correct location or not.*
Mapping of location/coordinates to actual position in library shelves	*Ensured whether it is picking or retrieving correct book not its adjacent books.*
Position accurately attained horizontally and vertically	*While picking books ensured that gripper arm does not touch nearby books as books were kept at distance from one another.*
Gripping action for holding book in position	*Bot does not drop books for most of the time. Gripper was closed in such a way that it did not loose grip in middle of operation.*
Movement along specified path only	*Bot was moving on correct path.*

6. Discussion of System

We have tried to cover almost all things as provided in plan for project. Bot is able to place and retrieve books as given commands from android phone. While placing books it initially scan barcode as provided on books. Book –id which is unique for each book is mapped to a particular location in arena. Then bot uses shortest path to reach its destination. As we were struck while trying to make Bluetooth connection with atmega2560 processor we made trade off in algorithm for retrieving books. Using android app user gives instructions to bot to retrieve books. Then user go to mapped location and retrieve it. First we tried to move bot using white line follower i.e localization of books using white line. But results were unsatisfactory. As a result of which we mapped book to a fixed location in a fixed arena. This time results were far better than white line follower so we used this for path tracing.
Initially we used LPC2148 bot but later on we came to know its difficulty while operating with gripper arm. So we switched to atmega2560 bot, in which in-built libraries were provided to control gripper arm.
We also planned to use wifi module but due to its non-availability we were given bluetooth module which was then used to make connection with bot.

7. Future Work

1) Right now bot is processing only one book at a time i.e retrieving or placing, so one possible extension could be processing multiple books at a time.
2) Now we have not consider obstacles while moving its destination, one can add that too.
3) One possible extension could be use of similar bot with some modification in shopping malls. In shopping mall there are a lots of items which have to be kept at different shelves. This activity requires a lot of human effort so we can replace it with bot of similar kind.

8. Conclusions

It was quite a challenging project. For the first time we were playing with hardwares without knowing anything about them. All four of us worked as a team and finally built an application which is able to perform tasks as planned by us. SRS helped us a lot while executing plan as it build up a clear picture of application which were going to build and we think it was an essential criteria to build up a plan and execute it. Our bot is able to retrieve and place books in their correct locations. It can be extended to place items in shopping malls which will save a large amount of human effort.

9. References

1. An Autonomous Assistant Robot For Book Manipulation in a Library, Ramos-Garijo R, Prats M, Sanz PJ, Del Pobil AP
2. Remote Book Browsing System using a Mobile Manipulator Tetsuo Tomizawa , Akihisa Ohya and Shin'ichi Yuta
3. https://github.com/zxing/zxing